INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory

Monthly Highlights

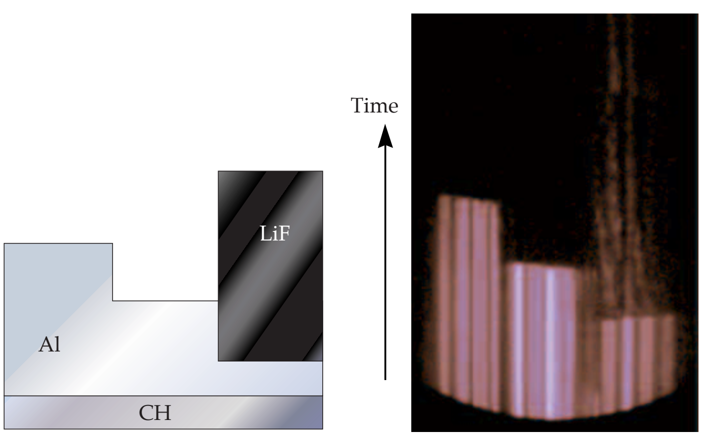
January 1999

UCRL-TB-128550-99-4

NIF LTAB. The shell of the NIF Laser and Target Area Building (LTAB) continues toward completion by Nielsen Dillingham, Inc. The 2.5-ft.-thick concrete wall for switchyard #2 has been poured to the +35-ft. level and formed to the +51-ft. level. The wall for the Target Area building has been poured to the +16.5-ft. level. The diagnostic building's basement walls have been poured to ground level, and the interior structural steel has been inserted.

The NIF LTAB in January 1999, as seen from the Target Area end.

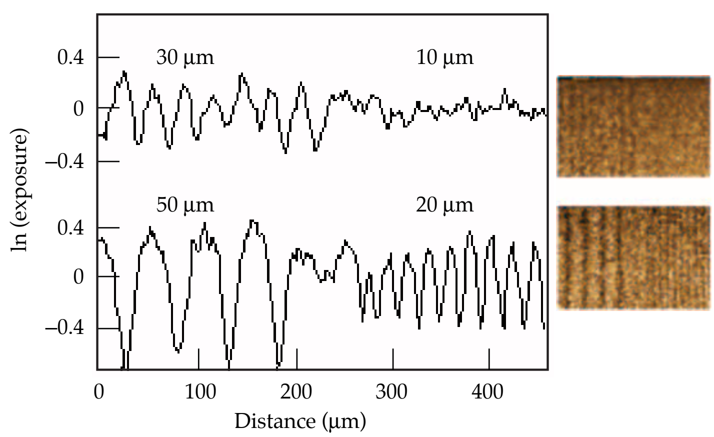
VISAR Installed on OMEGA Laser. A VISAR (velocity interferometry system for any reflector) has been installed at the University of Rochester's OMEGA laser facility to study shocks in materials. Shown below is an example of the streaked data from a stepped target used for equation-of-state (EOS) studies, demonstrating good shock planarity. The instrument uses a table-mounted interferometer with collection optics mounted in a ten-inch manipulator. In addition to the EOS studies, the system will support upcoming weapons physics and ICF shock timing experiments on OMEGA.



Streaked VISAR data on OMEGA showing good shock planarity.

NIF Optical Fiber Developed. The NIF precision power diagnostic design uses a high-bandwidth, low-attenuation, graded-index, ultraviolet-transmitting (351-nm) optical fiber, which has been developed by the Vavilov State Optical Institute, St. Petersburg, Russia. Such fibers, up to 40 m in length, transmit optical signals to transient digitizers. In order to meet NIF requirements, the fibers must contain many modes to reduce speckle noise: this can be accomplished with bundles of 19 100-µm-core fibers accurately cut to give the same time delay (±25 ps). With our Russian colleagues, we have recently demonstrated a cheaper and better solution using an equivalent 435-µm-core fiber. By carefully grading the index profile and controlling impurities, we have demonstrated that such a large-core fiber can have a dispersion of <1 ps/m and an attenuation <150 dB/km at 351 nm, meeting NIF requirements.

Rayleigh–Taylor Experiments Completed. We have performed the first conclusive steady-state measurements of the short-wavelength cutoff for indirectly driven Rayleigh–Taylor instability growth. The measurements were done on an aluminum package with perturbations of varying initial wavelengths. The hohlraum drive was engineered to provide a constant acceleration for ~2 ns. Shown below are two images of the raw data alongside lineouts in units proportional to optical depth, at $t \approx 5$ ns, showing strong growth at wavelengths of 20, 30, and 50 μm and little growth at 10 μm. This confirms an important stabilization effect for ablatively accelerated material.



Amplitude of perturbations at several wavelengths for RT instability at an aluminum ablation front.

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INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory

Monthly Highlights

February 1999

UCRL-TB-128550-99-5

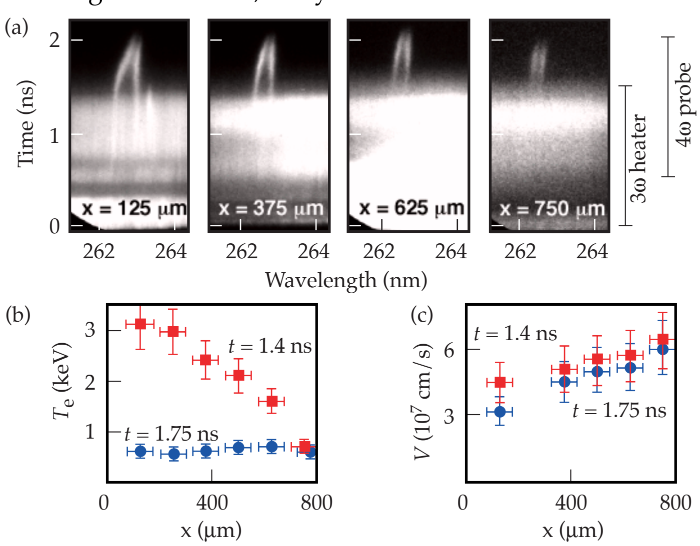
The NIF target chamber's first holes are drilled; there will be 190 holes in all.

NIF Target Chamber Status.

The National Ignition Facility (NIF) target chamber is a 10-m-diameter, 111-mm-thick, aluminum sphere vacuum vessel. It was fabricated from 18 plates welded in the same configuration as the panels of a volleyball. The first of the 190 holes, varying from 254 to 1800 mm in diameter, are being machined into the sphere (see photo). Within each hole, a flange will be attached, which will permit mounting of the laser final optics assemblies (FOA) and diagnostics to the chamber. The chamber will be moved into its final position in the NIF building in early June.

Thomson Scattering on Nova.

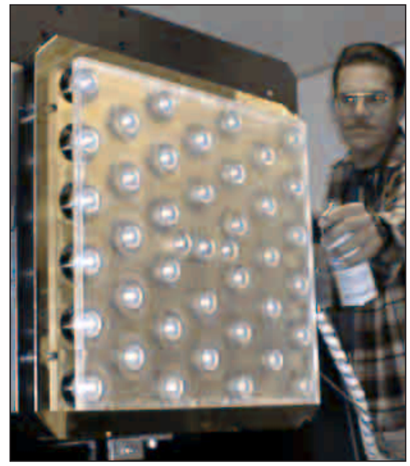
Thomson scattering has been used to diagnose electron temperature and flow velocity in gas-filled–hohlraum and open-geometry plasmas. Experiments have allowed detailed comparisons with integrated radiation-hydrodynamic modeling of laser plasmas and have shown close agreement. Benchmarks of such models greatly improve the understanding of the performance of NIF target hohlraums, a key to the NIF's success.



(a) Thomson scattering data from four different spatial positions in a gold disk target together with the analyzed spatial profiles of (b) electron temperature and (c) flow velocity.

NIF Deformable-Mirror Qualification Tests Completed.

The NIF wavefront-control system relies on deformable mirrors (DMs) to correct laser phase aberrations that would otherwise distort the laser focal spot, thus impeding the delivery of laser energy to its target. A prototype full-aperture (40-cm) DM, shown below, was built and tested at Lawrence Livermore National Laboratory (LLNL) in February. Laboratory tests showed the DM to have a residual surface correction error well within NIF requirements. A DM model was built from the measurements and inserted into a NIF optical system model that includes estimates of all aberrations. Calculations predict that the wavefront-control system will increase laser power into a 250-μm spot by a factor of 3.6.



The prototype NIF 40-cm deformable mirror.

Laser Glass Pilot Production.

Both Schott Glass Technologies (Duryea, PA) and Hoya Optics (Fremont, CA) have started their pilot production efforts to produce laser glass using continuous melting technology. Each company has formed the NIF laser glass at full NIF thickness and width. Early indications are that platinum inclusions and homogeneity will meet NIF specifications, but further testing and annealing are needed. These pilot-production campaigns will continue through the summer, with further results comparing glass properties against all the NIF requirements available this fall.

NIF laser glass pilot production efforts are under way.

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INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory

Monthly Highlights

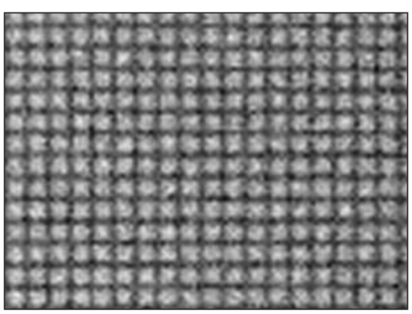
March 1999

UCRL-TB-128550-99-6

NIF Target Area Building Taking Shape. The NIF Target Area Building forming is complete to the +33-foot level. The concrete floor has been poured to the +17.5-foot level. The target chamber is scheduled to be moved into the center of the Target Area Building in June of this year. The photo below shows the structure as seen from above.

The NIF Target Area Building in March 1999.

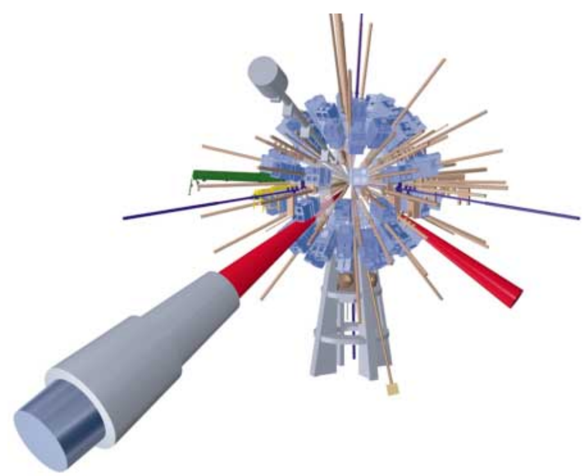
Bent X-Ray Crystal Microscope. When microscopes get close enough to "see" a typical high-energy laser-fusion experiment with adequate resolution, they are easily damaged. In March, we began testing of a spherically bent, x-ray crystal microscope designed to minimize this problem. These experiments, done on the Nova laser in collaboration with Naval Research Laboratories, used a 2-mm-aperture, quartz 2023 crystal to image a gold-wire resolution grid, using a quasi-monochromatic x-ray line at 4.53 keV as a backlight source. Result of offline tests indicate a resolution (i.e., 10 µm edge response) in agreement with predictions. The Nova tests showed similar performance but with less contrast. Future tests at higher energies and brightness will examine the microscope's potential application to NIF experiments.



Test image of a 25-µm-period grid successfully obtained with the bent-crystal microscope.

Preamplifier Module Testing. We have recently completed the first in a series of 50-shot performance experiments on NIF's engineering prototype preamplifier module (PAM) laser system. The PAM's role is to initially shape and amplify the beam before it is injected into the main amplifier system. NIF target experiments will require from the PAM extremely good shot-to-shot pointing stability (±0.81 µrad for a 372-mm beam) and energy stability (3%); the purpose of these experiments was to demonstrate routine PAM operation at a repetition rate of one shot every ten minutes for an eight-hour period. The measured energy stability of the PAM was 2.6%, meeting the NIF specification. The measured pointing stability of ±1.4 µrad has revealed several needed mechanical improvements in the PAM, specifically more robust optics mounts and nitrogen/air flow inside the PAM enclosure. These improvements are under way.

Workshop Aimed at Target Diagnostics of Large Fusion Lasers. A workshop on Target Diagnostics for Large Laser Fusion Facilities was held in Monterey, California, in early March. Attendees representing the national laboratories, universities, and other institutions reviewed core target diagnostics (i.e., the first to be installed on NIF) and their specifications. The groups then considered what additional diagnostics are needed to complete the NIF objectives and identified the research and development needed for these additional diagnostics. The groups proposed who might undertake various aspects of the research and development. Results are available from the ICF/NIF Program office.



The NIF's target chamber diagnostics are the topic of nationwide discussion.

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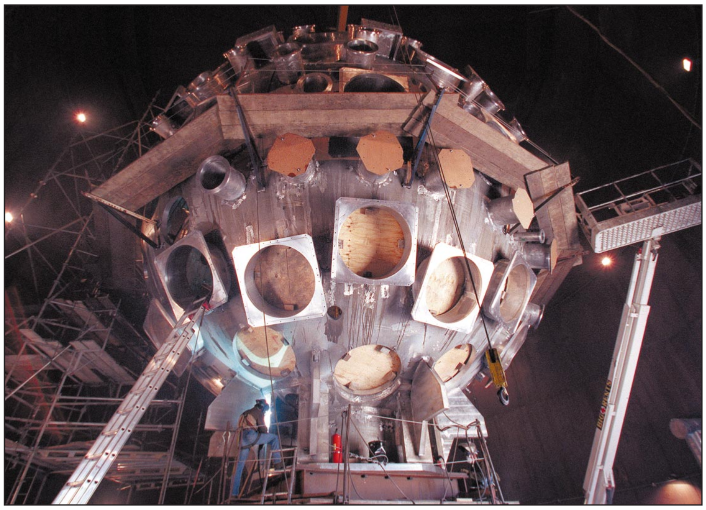
Monthly Highlights

April 1999

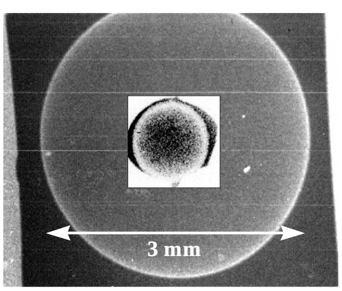
UCRL-TB-128550-99-7

NIF Target Chamber Preparing for Move. The National Ignition Facility (NIF) target chamber, scheduled to be moved from its assembly enclosure to the target area of the main facility building in June, is nearly complete. The 192 holes are being fitted with flanges that will allow the installation of the final optics assemblies and target diagnostics. The completion and movement of the target chamber are a major milestone in the NIF Project.



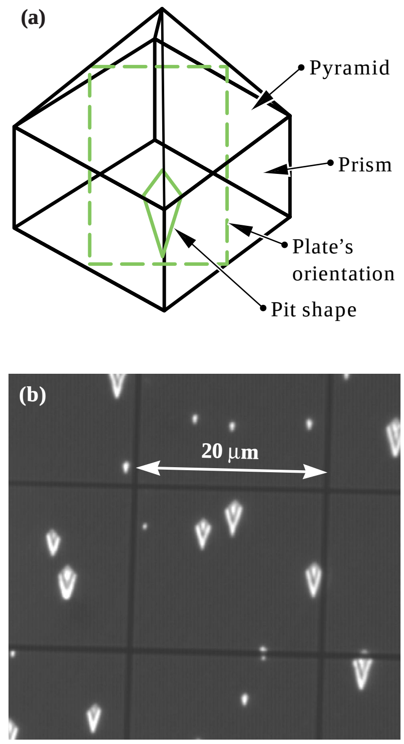
These flanges around the target chamber holes will allow the final optics assemblies and target diagnostics to be installed.

New Radiography Technique for NIF. Taking radiographic images during an ICF experiment is an important diagnostic capability. Previous multi-keV radiographic techniques have used either point-projection imaging from a fiber source or a pinhole image from a large-area source. A new point-projection x-ray radiography technique employing backlit pinholes combines the best features of both methods. The technique was recently used to backlight imploding shells in NIF-scale hohlraums. The figure to the left compares a 4.7-kV radiograph recorded by a backlit pinhole with a radiograph recorded using the traditional technique of area backlighting shown in the inset. NIF radiographic experiments that would have required up to 100 NIF beams to produce an area backlighter will now be feasible using just a single NIF backlighter beam per image.



The backlit-pinhole radiograph offers better signal-to-noise ratio than a traditional, area-backlit radiograph (inset).

KDP Scatter. Recent experiments clarified the formation mechanism of scattering defects observed in Beamlet frequency-conversion crystals and demonstrated that the defects do not occur in dry air. Ambient moisture is absorbed by the porous coating, which dissolves the potassium dihydrogen phosphate (KDP) and wicks it into the coating. The resulting etch pits in the crystal surface are characteristic of the orientation the plate is cut from the crystal, as shown in the figure. We have found that etch-pit formation is slowed substantially by annealing the crystal after final finishing.



(a) Etch-pit defects share the orientation of the plate to be cut from the crystal. (b) Photo of etch pits in a KDP frequency-doubling crystal.

National Workshop Addresses Direct Drive on NIF. Fusion ignition by inertial confinement can be achieved both by indirect and direct drive (i.e., by direct laser illumination of a deuterium–tritium target). While NIF will begin operations in indirect-drive mode, its target bay is designed to accommodate reconfiguration to direct-drive mode. A workshop was held at Lawrence Livermore National Laboratory on April 9 with the University of Rochester's Laboratory for Laser Energetics and the Naval Research Laboratory (the two main U.S. centers for research on direct drive) and General Atomics. A schedule was proposed for early planar drive experiments and the facility reconfiguration following the indirect-drive ignition campaign. Action teams were formed to address detailed issues for subsequent meetings. For more information, contact NIF Mission Support at vanwonterghem1@llnl.gov.

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Monthly Highlights

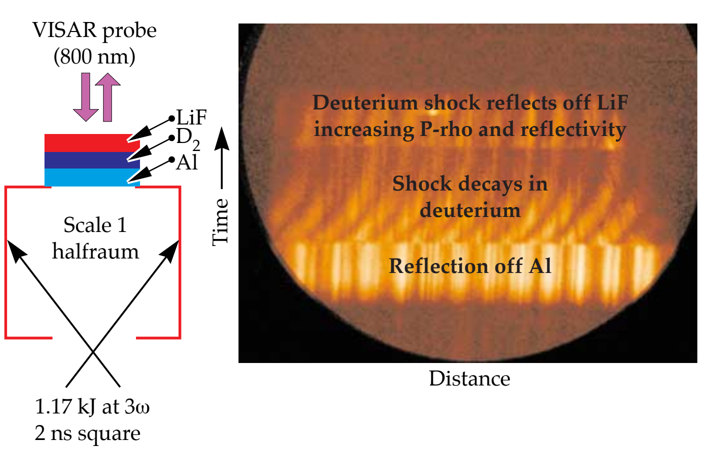
May 1999

UCRL-TB-128550-99-8

NIF Project Pours Foundation for Laser Bay Two. The foundation for the National Ignition Facility's Laser Bay Two is now in place, allowing the beam path supports to be constructed beginning in June. The pour, which was done in 11- and 6-hour blocks spaced six hours apart, required more than 3700 cubic yards of concrete (~370 truck loads) at 300 yards per hour.

The foundation for NIF Laser Bay Two being poured.

Deuterium Properties Measured at Higher Compression. Previous experiments have measured properties of deuterium on the principal Hugoniot up to 3 Mbar. To extend these measurements to higher compression, we have used a double-shock experiment whose setup is shown below at left. The fringe position from a velocity-interferometer-system-for-any-reflector (VISAR) record (shown below at right) is proportional to the velocity of the reflecting surface. The VISAR record shows fringes initially from the stationary Al ablator at the bottom of the streak record; a decaying shock in the deuterium; and finally the slowly decaying double-shocked deuterium–LiF interface after the deuterium shock hits the LiF. The second shock state in deuterium is determined from the equation of state of LiF, the instantaneous shock velocity in deuterium just before hitting the LiF, and the instantaneous particle velocity of the LiF just after impact.



The setup on the left yields the VISAR record on the right.

Tinsley Opens Precision-Optics Facility. A new 30,000-square-foot manufacturing center to produce precision optical components for the National Ignition Facility (NIF) was dedicated in Richmond, CA, on May 18 by the Tinsley division of Silicon Valley Group (SVG), San Jose, CA. The SVG center, together with facilities at Zygo in Middlefield, CT, and Eastman Kodak in Rochester, NY, will be used to fabricate the thousands of precision optical components needed to build NIF. This facility will be staffed by about 40 SVG engineers and skilled technicians, who will utilize one-of-a-kind, computer-controlled precision manufacturing equipment.

Tinsley's new precision optics manufacturing center in Richmond, CA.

Nova Laser Shuts Down. The Nova laser facility has been operating since early 1985. Since that time, approximately 14,000 experiments have been performed for inertial confinement fusion (ICF), weapons physics, and basic science. Nova has completed its ICF mission and is being decommissioned in preparation for the National Ignition Facility (NIF). The last experiment occurred on May 27 by Kim Budil in a weapons physics investigation. Nova is currently being disassembled and its space will be reused in support of NIF and other ICF activities. Many of the components will be distributed to various institutions as a result of a DOE disposition process.

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Monthly Highlights

June 1999

UCRL-TB-128550-99-9

"The great value of international cooperation is not the sharing of costs, but the sharing of minds."— Secretary Richardson.

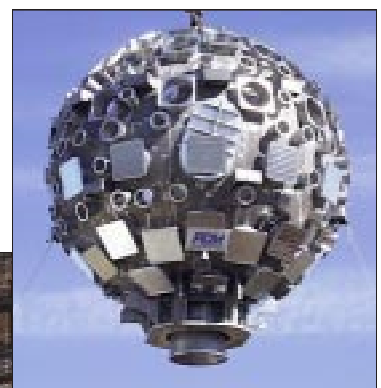
NIF Day Draws Impressive Crowd. Mike Campbell, Associate Director for Lawrence Livermore National Laboratory (LLNL) Laser Programs, welcomed a large audience of employees and visitors at NIF Day, June 11. He then introduced LLNL Director Bruce Tarter, who presided over the ceremonies. Tarter provided a brief history of the NIF (National Ignition Facility) and spoke of the target chamber's significance. "This is one of the most visible manifestations of the tools necessary to perform stockpile stewardship," he said. He added that the NIF would also fulfill all aspects of the U.S. Department of Energy's (DOE) missions: national security, science, energy, and the environment.

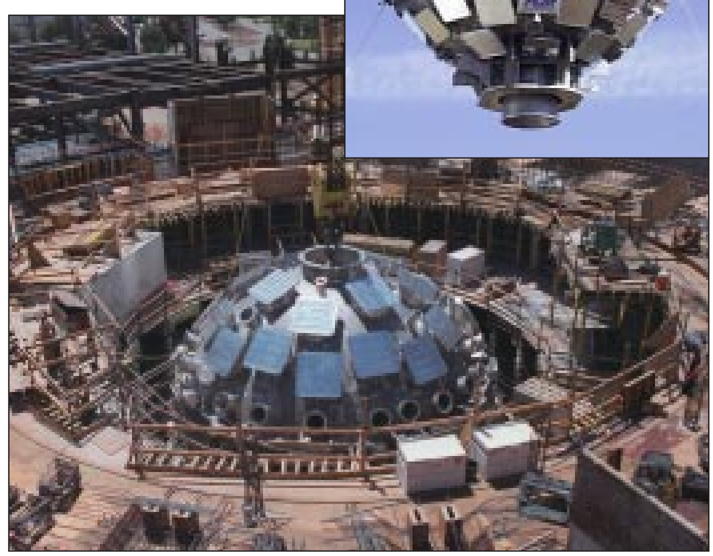
DOE Secretary Bill Richardson followed Tarter, noting that "NIF is the biggest science project under construction in the U.S. NIF will create a new standard for technological achievement." Richardson also stated that "NIF will be used to keep the nuclear arsenal safe without nuclear testing, making it crucial to keeping the nuclear deterrent reliable while advancing science."

Following Richardson's remarks, Jacque Bouchard, Director for Military Applications at Commissariat a l'Energie Atomique in France, and Graham Jordan, Deputy Under Secretary for Science, Ministry of Defense, United Kingdom, addressed the NIF Day crowd. "I wish the achievement of NIF and LMJ a complete success," said Bouchard. "I am confident in the validity of our basic assumptions, on the utility of laser experiments for science and peace." Jordan congratulated the NIF team, adding that "this joint venture, which is vital to both our nuclear deterrent programs, will further cement the very close and productive relationships which the United Kingdom and the United States have enjoyed in nuclear defense matters for over 40 years."

Other speakers were Wayne Kennedy, Senior Vice President for Business and Finance, University of California (UC), and Cathie Brown, Mayor of Livermore. Guests included Marty Domagala, DOE/Oakland Operations Office; Sue Johnson, UC Regent; Vic Reis, Assistant Secretary for Defense Programs, DOE; and LLNL Director Emeritus Edward Teller.

Target Chamber Milestone Reached. NIF Day celebrated the on-time completion of the NIF target chamber, where nuclear explosion simulations and fusion energy and other scientific experiments will take place. The 150-ton, 35-foot-diameter target chamber was built by Pitt-Des Moines Inc. of Pittsburgh, PA. On June 17, a specialized Manitowoc 4600 Ringer crane moved the 150-ton NIF target chamber into the target area portion of the Laser and Target Area Building, constructed by Nielsen Dillingham of Pleasanton, CA. The target chamber will receive over 400,000 pounds of optics equipment and a 400,000-pound concrete covering in the upcoming months.





The 150-ton, 35-ft-diam NIF target chamber moves toward the target area building (see inset). The Manitowoc supercrane places the NIF target chamber into its final position.

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Monthly Highlights

July 1999

UCRL-TB-128550-99-10

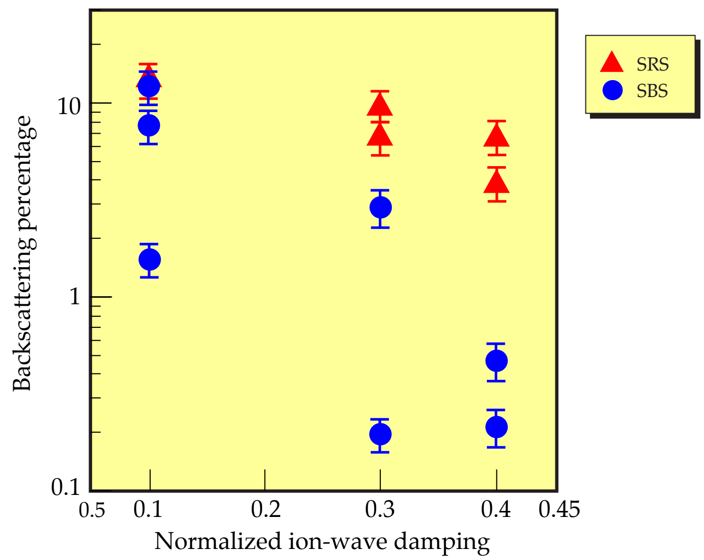
NIF Laser Bay 2 Pedestal Construction Under Way. Formation of the concrete pedestal for Laser Bay 2 in the National Ignition Facility (NIF) Laser and Target Area Building (LTAB) advanced significantly in July (see photo below). Crews continued installation of wallboard and put in place two 25-ton cranes. This work is part of an overall shift in construction from conventional facilities to the LTAB infrastructure, around which the special laser equipment will be built.

Laser Bay 2 concrete pedestal forming continues.

B381 Conversion Complete. Conversion of Lawrence Livermore National Laboratory's Building 381 high bay area, previously used for the Beamlet laser, was completed in June. The area (see photo below) will be used for building the National Ignition Facility (NIF) lasers. It now includes a large, Class 100 clean room with close temperature control to meet the stringent requirements for buildup of the bus-size NIF frame assembly units. Following assembly and alignment verification, these units will be installed in the LTAB laser bays, where they will house the large glass amplifiers.

The old Beamlet high bay area is ready to begin its new role—building NIF lasers.

Cryogenic Gasbag Experiment Complete. Laser beams in a National Ignition Facility (NIF) hohlraum will encounter laser plasmas having high ion-wave damping levels, which could potentially increase the amount of undesirable laser backscatter. To investigate this effect, we conducted a Nova experiment using a kinoform phase plate (KPP)-smoothed, $f/4.3$ beam (2×10^{15} W/cm^2 at 351 nm) and 3-mm-diam, cryogenically cooled gasbag targets spanning a range of ion damping values and electron temperatures. The graph below shows that as the ion damping increases, stimulated Raman backscatter (SRS) decreases slightly from 10 to 7%, and stimulated Brillouin backscatter (SBS) decreases from about 10% to below 1%. These results give us confidence that high ion damping in NIF hohlraums will not cause significant backscattering.



High levels of ion-wave damping in a NIF-like gasbag target do not appear to increase stimulated laser backscattering.

Science Workshop. Richard Petrasso from the Massachusetts Institute of Technology is organizing a workshop, Frontier Science at the National Ignition Facility: Episode I, October 4–6, 1999, in Pleasanton, CA. The purpose of the workshop is to plan cutting-edge physics experiments that will exploit the unique capabilities of the National Ignition Facility. Details of the agenda, registration, and announcement can be found at www.dp.doe.gov/ifnif/workshop.html, or contact Rich Petrasso at petrasso@psfc.mit.edu.

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Monthly Highlights

August 1999

UCRL-TB-128550-99-11

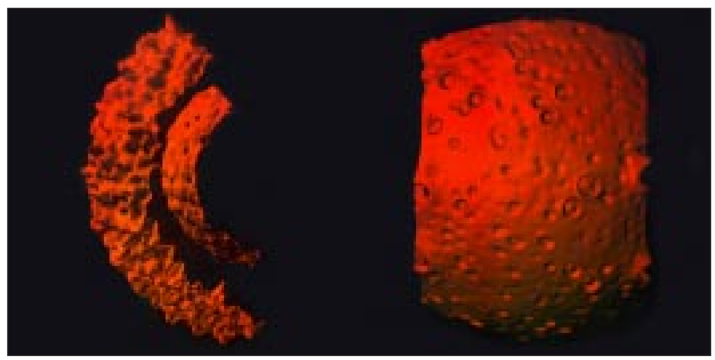
Switchyard Two Support Structure Up. The support structure for the National Ignition Facility's (NIF's) Switchyard Two is 30% assembled (see photo below). This structure, which will allow for precision installation and welding, is the skeleton for the beam tubes, mirror mounts, and other components that will direct the 192 laser beams from the laser bay into the target chamber. It is 92 feet high, and its 1200 tons of steel fill a million cubic feet of space. Agra Coast is putting up the structure, with Rigging International doing the installation.

The NIF Switchyard Two support structure, 30% complete.

NIF Transporter Successfully Tested. The first acceptance test procedure (ATP) was successfully completed for the first transporter of the National Ignition Facility (NIF) Laser Bay Transport System (LBTS) by the vendor in Charlotte, North Carolina. The transporter is an automated, laser-guided vehicle that will be used to move and install the majority of the line replaceable units (LRUs) that make up the NIF laser system. The transporter is scheduled to be shipped to Lawrence Livermore National Laboratory in the second week of August, after which a second ATP will be performed. Integrated tests will then demonstrate the transport, installation, and removal of an LRU into a structure simulating the enclosures in the laser bay.

The laser-guided vehicle that will install NIF laser system components.

3D NIF Capsule Simulations. A large, solid-angle 3D HYDRA simulation has modeled a 72° sector of a National Ignition Facility ignition capsule to study hydrodynamic instability growth from surface roughness. The simulation has resolved simultaneously the full range of modes most dangerous to capsule ignition. This problem was generated in parallel on a mesh of over 16,486,000 zones and run on a full sector of the Accelerated Strategic Computing Initiative SKY platform using 1680 processors. The figure below shows (a) two surfaces of constant density prior to ignition. The outer surface shows nonlinear perturbations in the outer ablator; the inner surface separates the hot spot and the dense fuel. Part (b) shows a contour of the rebounding shock at ignition time. The calculated yield of 15.4 MJ was close to the 1D yield of 17.1 MJ.



(a) Two isodensity surfaces prior to ignition. (b) Contour of the rebounding shock at ignition time.

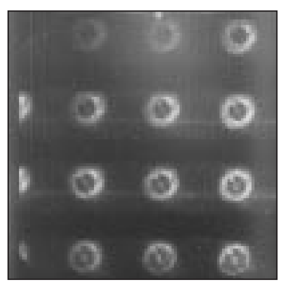


Image captured by 4k × 4k CCD on a double-shell implosion experiment.

CCD Imaging System Successful on OMEGA Laser. The use of a charge-coupled-device (CCD) camera in inertial confinement fusion experiments enables quicker turnaround on data and better signal-to-noise performance than film, while offering similar spatial resolution. In August, a high-resolution CCD was successfully fielded on the Lawrence Livermore National Laboratory (LLNL) experiments at the OMEGA Laser Facility in Rochester, New York. The CCD, which collected data from the primary experimental diagnostics, has a 4000 × 4000 pixel array. Each pixel is 9 μm square. The camera was jointly developed by LLNL's Y and A Divisions, the University of Rochester's Laboratory for Laser Energetics, and Bechtel Nevada.

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INERTIAL CONFINEMENT FUSION
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Monthly Highlights

September 1999

UCRL-TB-128550-99-12

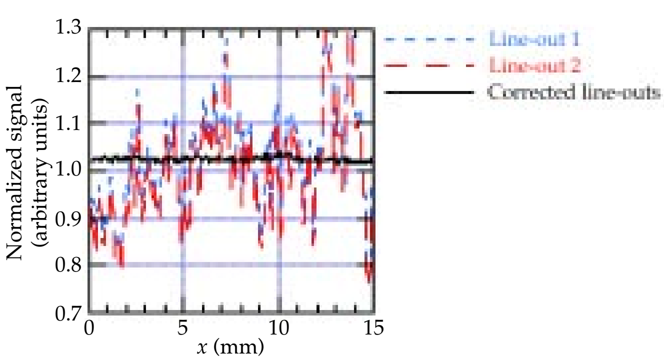
Precision Diagnostic System Chamber Installed.

The chamber that will hold the National Ignition Facility's (NIF's) precision diagnostic system 3ω diagnostic was installed into the Switchyard 2 structure in September. The vacuum chamber was adapted from its former use in the Beamlet laser, and was lifted into position (as shown below) by the Manitowoc crane, which placed the NIF's target chamber in June. The 8- × 36-foot chamber will be activated as part of the 3ω diagnostic in February 2002.

The precision diagnostic system chamber moves into Switchyard 2.

Low-Noise Gated X-Ray Detectors.

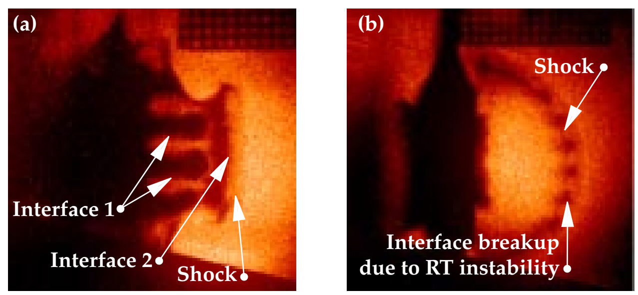
We have recently removed two sources of noise that have plagued gated x-ray data for years. First, we have replaced the film recording medium for microchannel-plate- (MCP-) based x-ray framing cameras with charge-coupled devices (CCDs). The CCD random noise level is 5 to 500× smaller than for film. Second, most noise in an MCP-based framing camera is discovered to be associated with nonuniformities in phosphor used for electron-to-light conversion. After correcting for this fixed-pattern noise, which is repeatable on spatial scales as small as 20 µm, the residual noise is reduced by a factor of 20. The graph below shows this repeatability and the drastic noise reduction.



Noise in MCP-based framing cameras before and after flat-fielding.

Astrophysics Experiments on the OMEGA Laser.

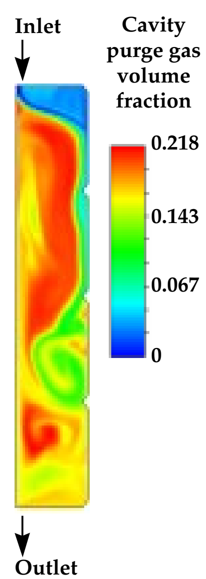
Scaled experiments have recently been conducted on the OMEGA laser at the University of Rochester to study the explosion hydrodynamics of core-collapse supernovae. In the first experiment, which studied hydrodynamic coupling between the oxygen layer and the outer He/H interface, three materials were used to simulate the radial density variation of a star. After the passage of a strong shock, an imposed perturbation at the first interface grows due to the Richtmyer–Meshkov (RM) and Rayleigh–Taylor (RT) instabilities, which seed growth at a second interface (see below left). The second experiment focused on the role of spherical divergence on instability growth in a supernova (see below right). Here, two layers in a hemisphere were exploded by laser irradiation, triggering RM and RT instabilities and causing the capsule to break up. This is similar to what happens to the outer two layers in a supernova.



(a) Two-interface coupling experiment; (b) spherically divergent experiment.

New System Cleans NIF Amplifier Beam Path.

Contamination control in the beam path of an ICF laser's main amplifier system is crucial for maximizing performance and minimizing refurbishment rates for optics. The National Ignition Facility (NIF) has developed a procedure and conceptual hardware design for a gas-purge technique that can clean up to 99% of the airborne contamination sources prior to optics installation. Firing the amplifier system's flashlamps at a high repetition rate for several hundred shots mobilizes the contamination into aerosols, which are then purged. This feature will also enable continuous contamination control inside the NIF beam path by producing an integrated, vertical-flow clean room during normal operations with the optics in place.



Fraction of original fill gas not displaced after gas purge.

For comments about content of the *Monthly Highlights*, contact Bob Kauffman (925) 422-0419.
To get on the mailing list of the *LLNL ICF Monthly Highlights*, *Quarterly Report*, or *Annual Report* send a request to carpenter13@llnl.gov
These reports and other LLNL ICF Program information are available on our Web page at http://lasers.llnl.gov/lasers/inertial.html
Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory

Monthly Highlights

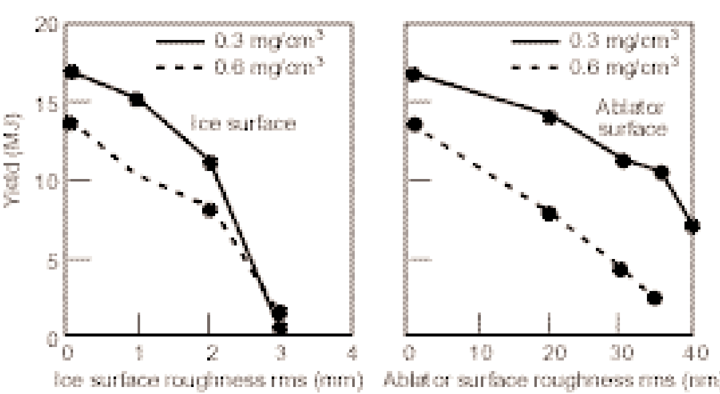
October 1999

UCRL-TB-128550-00-01

Optics Assembly Building. The National Ignition Facility (NIF) Optics Assembly Building construction has been completed, and commissioning tests are started. The clean-room protocols are well advanced, and the Class 100 area shown here has been completed. The Optics Assembly Building Management Prestart Review process is being initiated to ensure that the physical systems, drawings, procedures, and personnel training are all in place before installation of the assembly and inspection equipment begins. The Management Prestart Review process is a critical step in the Integrated Safety Management work authorization process.

Class 100 clean room in the Optics Assembly Building.

NIF Targets at Higher Cryogenic Temperature. Ignition targets generally perform best at a cryogenic temperature of 18.7 K, which produces a central deuterium-tritium (DT) gas density of 0.3 mg/cm^3. Recent work on cryogenic layer characterization suggests that the layer may be substantially smoother at higher temperatures—close to the triple-point temperature of 19.8 K, where the gas density is 0.6 mg/cm^3. Simulations of Rayleigh–Taylor instability growth on a baseline polyimide target, shown below, indicate that, although performance is reduced and surface roughness specifications are tighter, the target will perform acceptably with plausible surface specifications at the higher temperature.

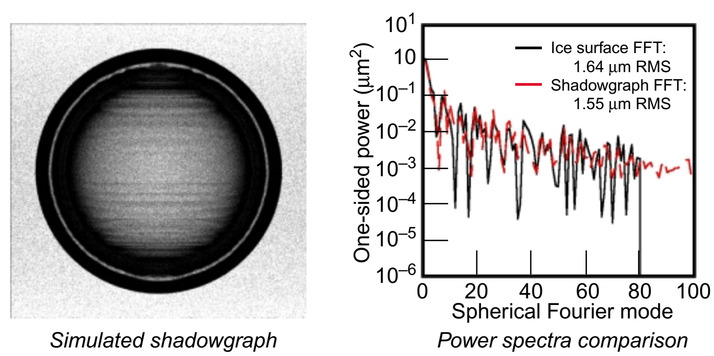


Comparison of NIF target yields for two different initial DT fill densities.

Frontiers in Science Meeting—Episode I. Scientists interested in using the NIF for basic science research met October 4 through 6, 1999, in Pleasanton, California. The meeting, organized by Dr. Richard Petrasso of the Massachusetts Institute of Technology, was attended by 175 scientists from the United States and other countries. The purpose of the meeting was to begin planning the use of the NIF for basic science experiments in the areas of radiation physics, astrophysics, hydrodynamics, material properties, nuclear physics, and inertial fusion energy. A highlight of the program was the keynote address by Dr. Steven Koonin, Vice President and Provost of the California Institute of Technology.

Dr. Steve Koonin delivering the keynote address.

Inertial Confinement Fusion Targets for the NIF. ICF targets will consist of a DT ice layer frozen to the inner surface of a solid shell. Backlit optical shadowgraphy is used to diagnose the smoothness of the ice. With this technique, the capsule is imaged in transmission, and light reflecting off the inner ice surface forms a bright band in the image. A 3D ray tracing code, SHELL3D, has been developed, which simulates this process and determines the accuracy of the shadowgraphy technique. The code generates a shadowgraph from a known ice surface, and the shadowgraph is then analyzed as if it were real data. The code has been used to demonstrate the correspondence between shadowgraph-derived power spectra and actual ice surface power spectra for mode numbers as high as 80, indicating that the diagnostic is sound. Future work will investigate optimum backlighting geometries and optimum bright-band position-fitting algorithms for data analysis.



SHELL3D-simulated capsule shadowgraph (left) and comparison (right) with actual data.

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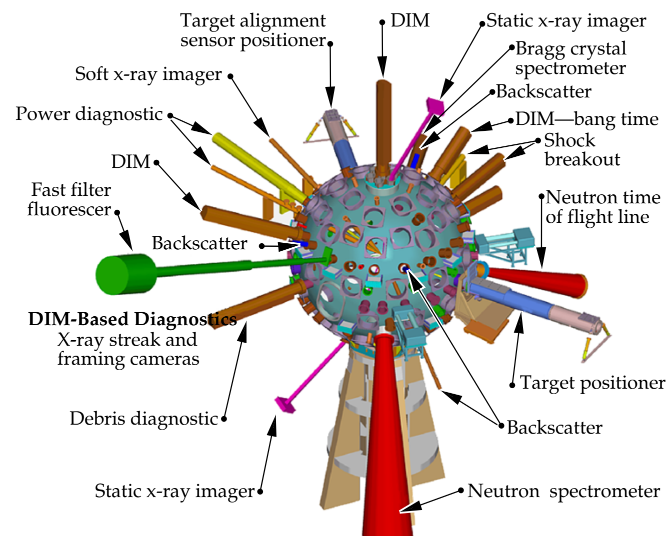
INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory

Monthly Highlights

November 1999

UCRL-TB-128550-00-02

Assignment of NIF Core Target Diagnostics. A memorandum of understanding has been signed by the Inertial Confinement Fusion (ICF) program managers agreeing to the scientific responsibility for the National Ignition Facility (NIF) core target diagnostics. These are the diagnostics needed for laser verification and for the early target experiments. The institutions involved in the design, construction, and initial deployment are Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Sandia National Laboratories, University of Rochester's Laboratory for Laser Energetics (UR-LLE), and the Naval Radiation Laboratory. These core target diagnostics will become part of the NIF diagnostic suite, to be operated and maintained by the facility. The assignment includes comprehensive use of diagnostic instrument manipulators (DIMs), as shown below, allowing diagnostics to be interchanged between different locations.



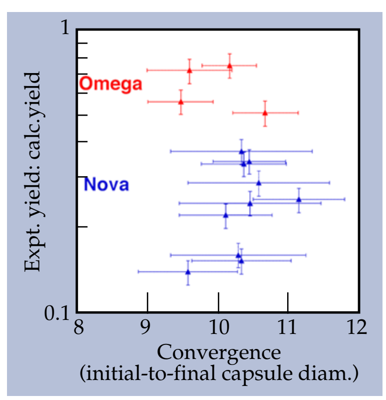
These core target diagnostics will be part of the NIF diagnostic suite.

Two New APS Fellows in ICF. The American Physical Society (APS) this month elected to fellowship Livermore researchers Michael Key and Peter Young. Both are members of the Lab's ICF Program. Key is the Lab's Deputy Scientific Director for ICF/NIF. He was cited by the APS for his pioneering work in the invention of the x-ray laser, for developing techniques to maximize laser output, and for originating the technique of x-ray backlighting. Young, the ICF Program's Group Leader for Plasma Physics, was recognized for his research into how intense laser pulses move through plasma. Such intense pulses create nonuniformity in the plasma, bending the laser light and refocusing it. Understanding this phenomenon is important in many applications, particularly ICF, where it is important to control the laser spot in order to better focus laser energy on target.

Target Chamber Boom Coming Together. The graphite fiber-reinforced composite boom for the NIF target positioner is under construction at the West Jordon, Utah, facility of R^3 Composites. The advanced composite was chosen both for its high stiffness-to-mass ratio, necessary to attain the low vibration amplitude (≈3 µm) required, and for its very small longitudinal coefficient of thermal expansion. The boom design envelope and vibrational characteristics were determined by LLNL; the composite selection, final configuration, and detailed layup design were done by R^3 in cooperation with their parent company, Composite Optics, Inc. The cylindrical section of the boom is laid up on aluminum mandrels in two sections that will form a 5.485-m-long final assembly.

The target positioner boom will place NIF targets in the Target Chamber.

OMEGA Experiments Show Improved Drive Symmetry. Recent experiments conducted by LLNL on the OMEGA laser at UR-LLE show the effects of improved drive symmetry. Low-convergence, 50-atm, deuterium-filled fusion fuel capsules have been shot at both OMEGA and at Nova (40 and 10 beams, respectively). The figure below shows each experiment's measured neutron yield divided by the calculated yield for that shot. OMEGA's superior yield reflects the larger number of beams (arranged in multiple "cones"), which enable the greater drive symmetry. The *x*-axis measures the ratio of the target's initial-to-final diameter; a larger convergence means greater fuel compression. NIF's 192-beam arrangement is similar to the OMEGA configuration, and can be expected to impart even higher drive symmetry than these results.



OMEGA's greater drive symmetry improves yield and convergence.

This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory

Monthly Highlights

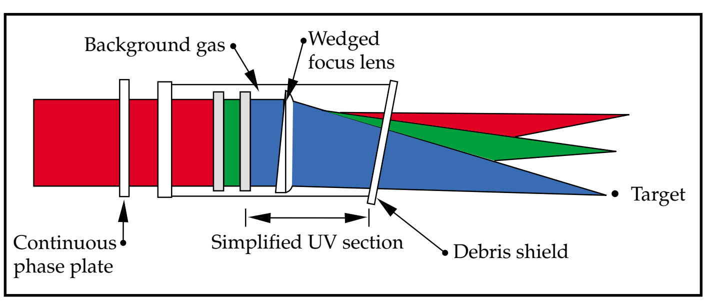
December 1999

UCRL-TB-128550-00-03

Target Chamber Shielding Installed. The exterior surface of the National Ignition Facility (NIF) target chamber has been covered with 40 cm of sprayable concrete, called "gunite." The gunite will serve a dual purpose during yield operations—it will reduce the neutron fluxes on components and structures outside the target chamber and protect personnel from gamma-ray fluxes. This shielding includes a boron additive to capture low-energy neutrons.

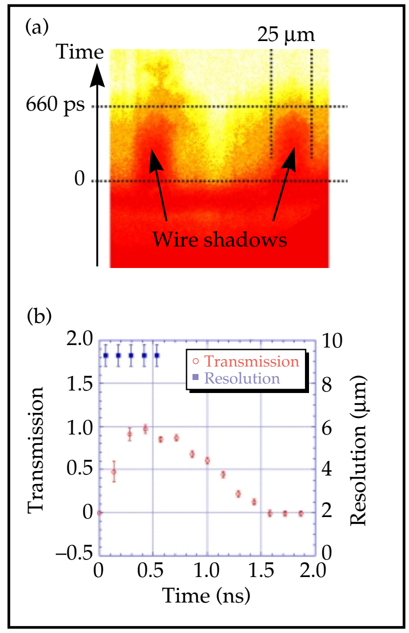
Gunite, a sprayable concrete, being applied on the NIF's target chamber exterior.

A Reconfiguration of the FOAs Aims to Correct Beam Orientation Problem. Recently we discovered that the arrangement of the NIF final optics assemblies (FOAs) when mounted on the target chamber would not exactly match the orientation of the beam arriving from the final turning mirrors. Redesign of the FOA to include a wedged focus lens will solve this misalignment, as well as eliminate the need for a color separation grating in the FOAs (see figure). This change in the lens design will require modifications to the design of other hardware in the target area, such as the relocation of the final turning mirrors, and rerouting of various utilities. A design to incorporate these changes is under way.



NIF's reconfigured final optics assemblies include a wedged focus lens.

Point-Projection Backlighting a Tool for Imaging NIF Targets. Pinhole-assisted point-projection backlighting has been previously demonstrated using 25- and 50-μm pinholes, but many NIF experiments require better resolution (10 μm or less). The key issue was the degree to which the backlighter x-ray source placed only 1 mm away (for providing a large field of view) would vaporize the pinhole substrate and close off the pinhole prior to completion of the experiment. Experiments on the OMEGA laser at the University of Rochester Laboratory for Laser Energetics have demonstrated 9-μm resolution pinhole point-projection imaging by 25-μm-diam tungsten wires [see Figure (a)]. Streaked 120× magnification images of the wires show pinhole closure only beginning after 500 ps [see Figure (b)], hence providing plenty of time for a backlighter snapshot.



(a) Images of 25-μm-diam tungsten wires with 9-μm resolution. (b) Plot of 10-μm tamped pinhole transmission, 1-mm pinhole-to-backlighter distance, and 0.5 TW on Ti backlighter.

NIF's First Major Beampath Infrastructure Contract Up for Bid. Final design for Construction Subcontract Package 13 (CSP-13) has been released to the Lawrence Livermore National Laboratory's Procurement Department. It has been prepared following NIF Project Procedures and submitted through the NIF product data management system for approval and document release. Procurement is in the process of inviting bids, which are estimated to range between $4 million and $6 million.

The work in CSP-13 is to set and align 24 large (50,000 kg) laser bay vacuum vessels and many other support structures. The chosen contractor will furnish labor, material, equipment, tools, and services required to transport, install, and align the government-furnished equipment and associated equipment in the two laser bays of the NIF. The package requires verifying embedment locations, setting and erecting equipment, precision alignment, structural fabrication, and installation of various components.

This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.